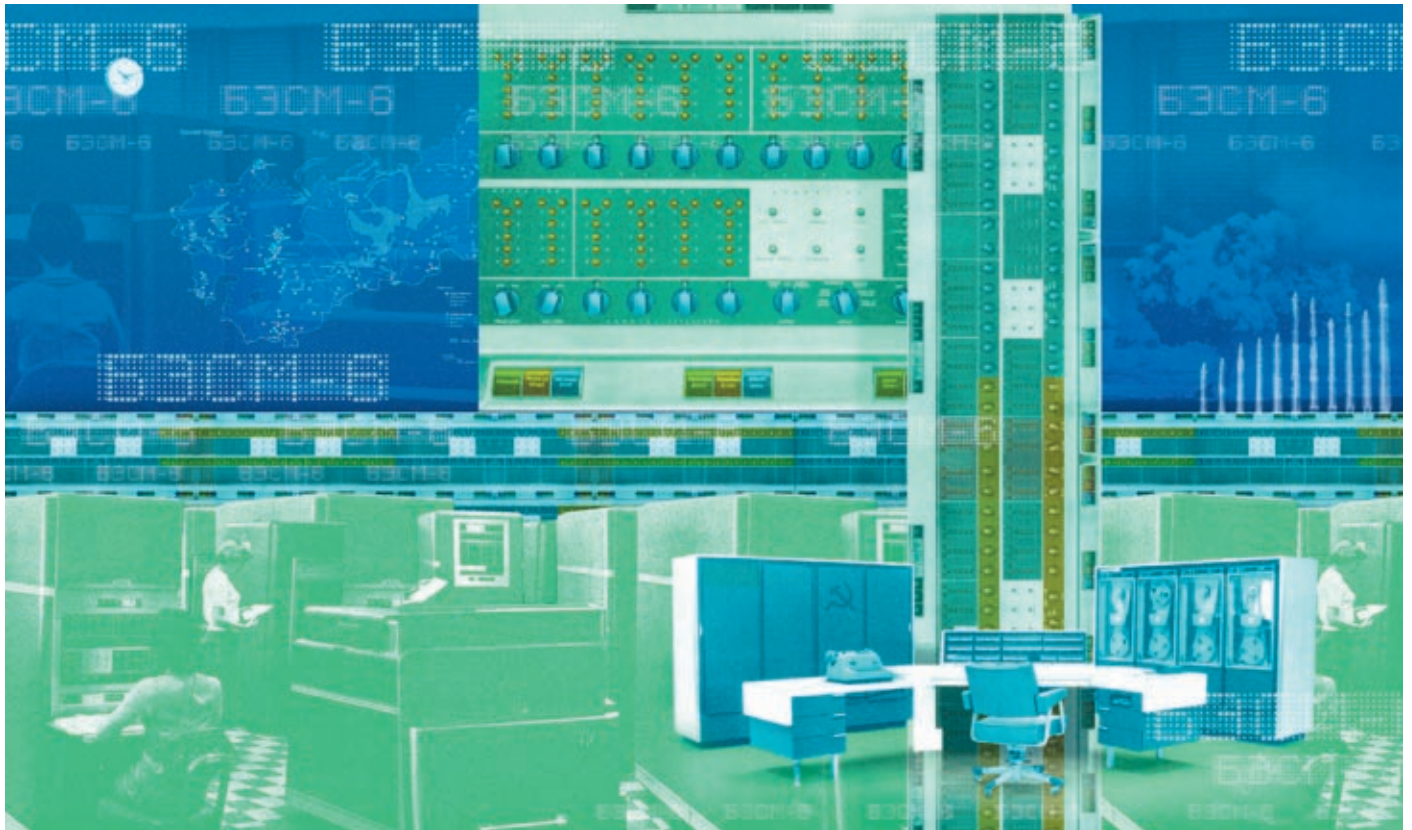




COLD WAR COMPUTING

Computers played a vital role in the Cold War battle for technological supremacy.

Jon Thompson looks at how espionage and sabotage affected the development of PCs behind the Iron Curtain

Just before the Iron Curtain descended across Europe, Soviet scientists had started hearing about the high-speed digital computers sweeping into laboratories and university departments in the West. World War II had supercharged the potential for technological progress, but the speed at which humans could perform the necessary calculations hindered the pace. Compared to a human, even primitive valve-driven computers performed miraculous feats.

The first electronic computer helped the boffins at Bletchley Park to crack the Nazis' supposedly unbreakable Enigma code. In the US, the military calculated accurate artillery-aiming tables. Soon, everyone wanted access to these computers and they took hold in the public's imagination. But these seemingly magical machines would also find themselves at the heart of a dangerous ideological conflict as governments began drawing Cold War battle lines. Knowledge of the capabilities of digital computing presented Soviet scientists with an opportunity to make giant leaps forward, but it also presented them with a problem, as Communist ideology demanded that

scientists discard Western methods. The eventual solution would have far-reaching implications decades later.

IDEOLOGICAL COMPUTING

In September 1950, Mikhail Lavrent'ev, director of Moscow's Institute of Precise Mechanics and Computer Technology, announced in a speech to colleagues that Soviet computing trailed the US by 15 years. Although they understood that machines could crunch numbers, their experiments had produced only a few primitive analogue machines.

According to public records stored at the Central Archive of Social Movements in Moscow, Lavrent'ev showed colleagues some pictures of machines in the West and told them: "Our task is clear. Within five years, we must catch up with foreign countries. We must eliminate the lag in high-speed digital computers. I am confident that our Institute will not betray the trust of the Government and Comrade Stalin, and will overtake and surpass foreign countries." This careful wording reflected the dangerous mood of the times; the 'Computing under Stalin' box on page 195 explains this in more detail.

A few physicists realised the need for serious number-crunching power and decided to play a dangerous game of politics. They decided to protect themselves and their staff from criticism that could result in them being sent to labour camps. Russian computer pioneers such as Sergei Lebedev of the Kiev Electro-Technical Institute declared that the new computers they wanted to build would glorify the Soviet state by carrying out only ideologically correct calculations.

Lebedev's announcement stunned many of his colleagues. Engineer Zinovi Rabinovich told Radio 4 recently through an interpreter at the Ukrainian Academy of Sciences: "We worked on automated management of space systems. Then in August of 1948, Lebedev told us that our laboratory would work on another problem, on computer science." It was an intriguing call to arms.

COLD FRONT

In a climate of international isolation and domestic suspicion, Lebedev assembled a secret team of 12 designers and 15 technicians at a disused monastery at Feofania, near Kiev. The city had been under brutal Nazi occupation during the war,



which had killed three-quarters of its population and destroyed half its buildings. After the team had made the place habitable, Secret Laboratory Number One was ready to start work.

Lebedev has been described as a genius and “the Soviet Alan Turing”. Archives at the National Academy of Sciences of the Ukraine show that Lebedev made steady progress despite not having access to Western knowledge. He began thinking about how to build a computer in 1948 and by the end of 1949 had the basic principles worked out. Once the lab was ready, progress was swift.

Rostislav Chernjak, one of the few living members of the original team, remembers the lab. “On the second floor was the laboratory and a larger room where we assembled the computer. It needed seven kilowatts of power so it was very hot and we needed cooling. We demolished a wall to make the room bigger, but that wasn’t enough. So we took the roof off.”

The machine they constructed was called MESM, which is short for ‘small electronic counting machine’ in Russian. It contained over 6,000 vacuum tubes and had its own small power station to overcome local supply difficulties. But running at just 3KHz, its performance was poor. Lebedev’s team realised that reading the results on its output display lamps was difficult and could produce errors, so they decided to invent their own printer. A resourceful engineer called Boris Malanovsky was responsible for cannibalising a number of printing cash registers to provide the necessary hardware.

THE FIRST PROGRAM

MESM ran its first test program in November 1950. The first program was a ballistics problem. To test the machine, MESM and two mathematicians, working in isolation, had to solve the problem:

$$Y'' + Y = 0; Y(0) = 0; Y(\pi) = 0$$

Lebedev quickly realised that MESM’s results were different to those of its human counterparts. After a day spent checking the machine, Lebedev stayed up all night trying to find the source of the problem. By the following morning, he had found it. The



The first Soviet digital computer, MESM, pictured with some of its original developers



The huge and massively underpowered Strela mainframe looked more impressive than it was. All seven production models would end their days in an early cluster

machine was right, and the mathematicians had both made the same subtle mistake.

MESM finally went into service on Christmas Eve 1951, making it arguably the first electronic computer in continental Europe and certainly the first within the Eastern Bloc. To put the machine’s 3KHz speed into perspective, Alan Turing’s Pilot Model Ace already ran at 1MHz. Even so, MESM received a flood of secretive visitors keen to perform equally mysterious calculations. Thanks to the end of the Cold War, we can now piece together what those calculations were.

At a time when enriched uranium was scarce and the physics behind making it explode were only vaguely understood, development of nuclear weapons was high on the Russian government’s list of priorities. Far larger explosions than the ‘simple’ atomic type could be created using an atomic bomb to fuse together hydrogen atoms to form a massive thermonuclear reaction. But the only way to be reasonably sure a fusion bomb would work was to model the complex sub-atomic processes involved.

According to the sociologist Slava Gerovitch, writing in the April 2001 edition of the journal *Social Studies of Science*, the atomic bomb – then the most potent symbol of political and military power – showed the clear superiority of Western physics. In the eyes of many Soviet officials, this state of affairs could not stand.

Then there was the problem of building a missile capable of firing such weapons accurately. The physics of inter-continental ballistics required large amounts of number crunching. At the time, the only source was Lebedev’s Secret Laboratory Number One.

THE BIG PICTURE

MESM was a groundbreaking proof-of-concept machine that opened the floodgates for Russian Cold War science. But its successor, the large electronic computing machine, or BESM, made an even bigger impact.

Completed in 1953 by Lebedev’s team, BESM-1 used around 5,000 vacuum tubes. Only one reached completion, but it was at the time the fastest in continental Europe. It used floating point to represent numbers using 39-bit binary words. Although it had only 1KB of ferric core memory and another 1KB of read-only subroutines, its four magnetic tape units were capable of storing 30,000 words each. For the high-speed backing store, there were magnetic drums that could store 5,120 words per unit with an access speed of 800 words per second.

The first Russian mainframe also arrived in 1953. The elegant but underpowered Strela was designed and built by the Moscow Plant of Computing Analytical Machines. This giant occupied 300 square metres of floor space, had 43-bit binary floating-point notation and used electron-beam tubes as RAM. The West knew these ingenious devices as Williams Tubes. The principle was that an electron beam could place a dot in any one of several positions on a phosphor screen, representing a binary bit. A mechanism read the places where the dots could appear and refreshed them until told otherwise. Constant refresh mechanisms are still the basis for DRAM today.

RACE AGAINST TIME: EAST AND WEST COMPUTING TRIUMPHS

During the Cold War, both sides had a habit of measuring their computers in terms of floating point operations per second (FLOPS) or millions of instructions per second (MIPS) rather than raw clock speeds. Where possible, we’ve used the same measures for both sides.

Until the policy of cloning Western machines came into operation in the late 1960s, Eastern bloc machines lagged behind their Western counterparts.

Progress in the West meant that the state of the art was always far faster than anything that the USSR could manage. When the futuristic Cray-1 emerged in 1976, it delivered exponential speed that was simply not possible using Soviet machines.

SOVIET MACHINES

1951
MESM
3KHz

1953
BESM-1
8-10KFLOPS
Strela
2KFLOPS

1958
BESM-2
10KFLOPS



1950



1951
Pilot Ace
1MHz

1952
EDVAC
1MHz

1954
IBM 650
2MHz



WESTERN MACHINES



The backing store for the Strela came from two magnetic tape units; these stored a combined 1.5 million 43-bit words. For data input, there was a punched card and magnetic tape. Each of Strela's subroutine libraries had 15 programs, which existed as a hardwired collection of diodes, each representing a sequence of up to 16 instructions. The instruction set was surprisingly modern, consisting of logical and arithmetic commands and conditional jumps. But the finished machines were very power-hungry. The central processing unit alone drew 75kW, and the cooling system and peripherals doubled this to 150kW.

Slava Gerovitch says that, despite a meagre 2,000 instructions per second, one of the first Strelas went into service at Moscow's Design Bureau Number One of the Third Chief Directorate. It apparently solved problems relating to the target destruction probability and detonation efficiency of fragmentation warheads.

Eventually, all seven production Strelas worked on nuclear and ballistic missile calculations at the Academy of Sciences' Division of Applied Mathematics. Arguably this was the first cluster, Linux versions of which now form the most powerful computing devices on Earth. In 1954, Strela designer Yuri Bazilevsky and his team received the Stalin Prize of First Degree. Production of the Strela stopped only in 1956.

TAKING LIBERTIES

There was increasing demand for computer time from civil researchers. This led to conflicts with the military over access to the precious machines. In 1955, the Computation Centre of the Academy of Sciences in Moscow became the first non-military computer bureau in Russia, with several computers from various plants to its name. Non-military researchers could supposedly run non-classified programs on these machines.

At least, that was the idea. The problem was that military researchers always had priority and so could muscle in on civilian computing time. By September of that year, the Academy had to set up a review committee to resolve bitter disputes over who should have access to computer time. The committee recommended that at least 20 per cent of the total time available should go to civilian

COMPUTING UNDER STALIN

After World War II, Russian science found itself under particularly tight ideological control as Cold War battle lines formed. The Soviet state demanded that its scientists "overtake and surpass" their counterparts in the West while rejecting foreign solutions to problems. Soviet physicists argued successfully that without Western theories such as relativity, they had no hope of creating atomic weapons. For computing, the situation required that things were invented from scratch.

In the paper *Mathematical Machines of the Cold War: Soviet Computing, American Cybernetics and Ideological Disputes in the Early 1950s*, Slava Geovich says that as the Cold War deepened, the Soviet press started to treat announcements of Western technological innovation as lies and propaganda. It became increasingly apparent that in areas such as computing and atomic power, the West had a clear advantage, even though the Soviet state demanded that scholars should "criticise and

destroy" Western ideas in print and debate. A major row broke out over the building and use of digital computers by Russian scientists.

At various times since Stalin had come to power, sciences such as genetics were denounced as "bourgeois pseudo-science". Despite the clear need for fast, reliable computers to match the pace of world progress, some academics and writers claimed that using computers to control machinery was "imperialist cybernetics" and that, as such, it reduced men to the status of mere mechanisms. If Stalin decided that computers were politically incorrect, some scientists would live out their remaining days in the infamous labour camps.

By 1955, however, two years after Stalin's death, the arms race had dispelled any Soviet qualms about ideology. In that year, nuclear and ballistic missile projects consumed practically every processor clock cycle available within the Eastern Bloc.

researchers. Stories persist that the committee was composed mostly of military project men who apportioned time according to their needs.

Things were no better elsewhere. Nuclear researchers, led by Igor Kurchatov, and the designers of missiles and spacecraft, led by Sergei Korolev, used up all the computing time they could find.

In James Hartford's book *Korolev: How One Man Masterminded the Soviet Drive to Beat America to the Moon*, Cosmonaut Gregorii Grechko recalled his experiences of trying to secure time as a young researcher on a typical machine: "Kurchatov's people used it in the daytime and during the night Korolev's people [used it]. As for the rest of Soviet science, maybe five minutes [was allowed] for the Institute of Theoretical Astronomy [and] half an hour for the chemical industry."

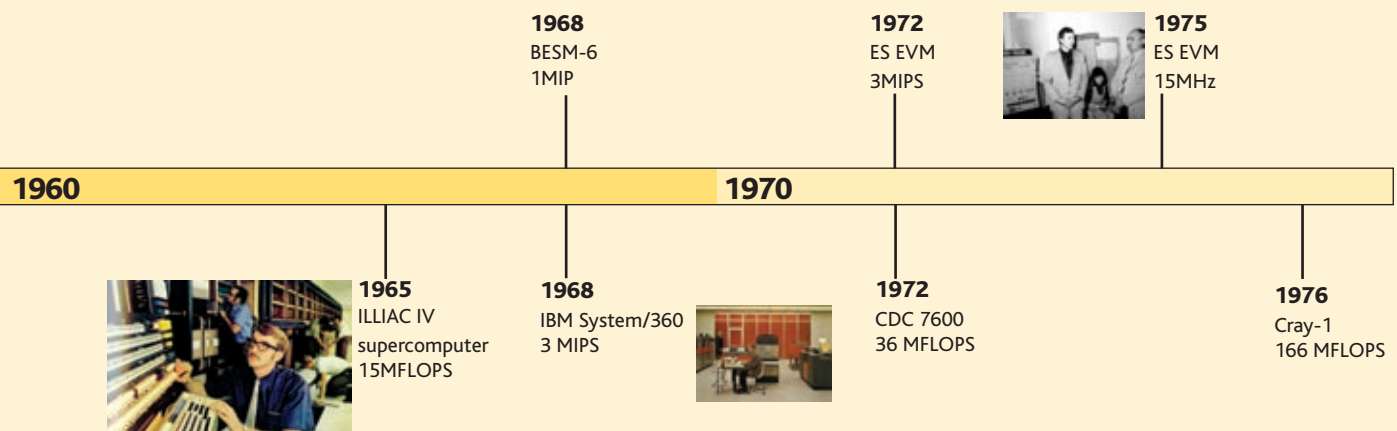
Meanwhile, at Secret Laboratory Number One near Kiev, Lebedev's next triumph was 1958's BESM-2 computer. This became the first machine designed by Lebedev's team to go into full

production. According to the Russian Virtual Computer Museum, the team, now numbering around 150, completed and shipped several dozen machines to institutes around Russia and even exported one to China.

The BESM-2 was a major improvement on earlier models. Again, it was a 39-bit machine, with a 39-bit memory bus. It doubled the size of the ferric core RAM to 2KB, with an impressive access speed of 10 microseconds. Processor speed was 10,000 instructions per second, but this was still very slow by Western standards. External storage came in the form of magnetic tape and drum storage. The BESM-2 also used punched tape entry, which it could read at 20 characters per second. Production ceased in 1962.

SIX SENSE

By 1960, the Soviet military began to see the computer's potential for planning, logistics and battlefield simulation. They wanted greater





number-crunching power. In 1967, the BESM-6 became the first Soviet supercomputer and it entered full production a year later.

Running at a then staggering one million instructions per second (MIPS), the BESM-6 had 192KB of ferric core memory, magnetic disk, drum and tape storage, punched card and paper tape input and even a few video terminals. The main memory and the control and logic units could all work at top speed and in parallel, thanks to a system of buffers between them, which stored intermediate results as they became available. To speed execution further, cache memory stored frequently used instructions to reduce the time taken to fetch them from RAM. The RAM featured stratification, which meant that several peripherals could access it simultaneously and made it possible to run a true time-sharing operating system.

However, what gave this 10MHz machine supercomputer performance was its ability to be at different stages of processing up to 14 instructions in parallel at any one time. Lebedev called this 'the principle of water pipe' in his notes. We would recognise it as the technique of pipelining instructions to improve the throughput of modern chips. Though Lebedev died in 1974, the 355th and final BESM-6 was produced as late as 1987.

FOLLOW THE LEADER

Lebedev invented pipelining independently, but much of the technology used in the BESM-6 wasn't Russian. It was copied from IBM. The Soviet leadership had started to view American systems enviously, and the order eventually came from the top to abandon many new developments and simply copy whatever IBM was doing.

In 1968, with help from the KGB, there began a project to clone the IBM System/360. This powerful machine was widely used in the West and even helped put man on the moon. Officially, the initial



The BESM-6 could handle up to 14 instructions at once, giving it supercomputer performance at a low clock speed



The Russian ES PEVM copy of the IBM PC, circa 1985

design of the cloned machines came from the Moscow Scientific Research Centre for Electronic Computer Machinery. However, the plans and even pieces of hardware reportedly came from the West.

The IBM System/360 was not available in the USSR due to restrictions imposed by the Coordinating Committee for Multilateral Export Controls (COCOM) agreement. This prevented the export of high-tech equipment to Eastern Europe from the West. In response, in 1972 Soviet leader Leonid Brezhnev told a meeting of officials: "We communists have to string along with the capitalists for a while. We need their credits, their agriculture and their technology."

In the same year, the ES EVM became widely available in Russia. Based on early versions of the System/360, this machine couldn't run as fast as the latest models in the West but it did run a Russian language version of OS/360 called OS ES. Russia produced 15,000 ES EVMs, only ceasing production in 1995. These general-purpose computers found a wide range of uses in science and industry.

In 1975, following on from the ES EVM's success, production started

on a clone of the Digital Equipment Corporation PDP-11/40 mini-computer. The PDP-11 range found widespread use in universities and industry. Called the SM-4 EVM, the Russian version came with an optional 128KB or 256KB of RAM, a paper tape unit for input, two removable 2.5MB disk packs and two 5MB fixed disks. It also featured multiple video terminals and twin magnetic tape units. The SM-4 so faithfully reproduced the original hardware that it even ran UNIX.

In the mid-1980s came the first IBM PC copy: the ES PEVM. This ran DOS and early versions of Windows. Supposedly developed in Russia, manufacture took place at the Minsk Production Group for Computing Machinery.

NOT-SO-FOND FAREWELL

US intelligence eventually realised the extent to which Western computer technology had started to appear in the Soviet Union. At a meeting between US president Ronald Reagan and France's president François Mitterrand in 1981, it emerged that the French had recruited a KGB agent in Moscow. Colonel Vladimir Vetrov, also known as 'Farewell', was responsible for evaluating Western technology. He had access to the KGB's Technology Directorate, which acquired Western technology for the regime to study and copy, and exposed the Directorate's technology wish list. The box on the left describes how the US government used this information to its advantage by allowing sabotaged technology to be stolen.

During 1984 and 1985, the US arrested and expelled large numbers of suspected KGB agents, effectively stemming the flow of technology. Given that domestic computers were seriously underpowered, and stolen Western technology had been doctored, the USSR faced uncertainty. It could no longer tell what the US had done or where, or what was going on in US computer labs.

For many years, Russian technology seemed doomed. However, the collapse of the Soviet Union brought a new spirit of freedom to the former Eastern bloc. The embargo on Western technology enforced by COCOM ran out in March 1994.

IBM now helps to maintain the ES EVM System/360 clones still in operation. Microsoft enjoys a strong, growing presence in the former Soviet Union, Linux is making steady advances and the open-source movement is also gaining ground. The United Nations Educational, Scientific and Cultural Organisation (UNESCO) reported that in April this year the first Open Source Forum took place in Moscow, bringing together members of the open-source community from the US, Europe and Russia. Sponsored by IBM, HP and Novell, this demonstrates how far things have come. It's a long way from the old monastery in post-war Kiev. **CS**

HOW THE CIA MISLED THE SOVIETS

According to Thomas Reed's book, *At the Abyss: An Insider's History of the Cold War*, in 1981 France shared vital intelligence with the US about Soviet technology-gathering activities. An agent called Farewell had access to the KGB's Technology Directorate and had supplied information, known as the Farewell Dossier. At the time, Reed was a member of President Reagan's National Security Council.

The dossier contained details of how far the KGB had penetrated Western technological endeavours. It had details of past acquisitions and agents in the field. The KGB had, the dossier claimed, even infiltrated goodwill missions set up in the 1970s to boost cooperation between the superpowers. Farewell exposed the extent of these activities and also contained a 'shopping list' of technology that the Soviets were keen to get their hands on. Reagan asked Director of Central Intelligence Bill Casey for ideas about how to use the information. The plan was to let the KGB steal whatever technology they liked, but only after special modifications had been made.

Stolen microprocessors would seem to pass initial quality tests only to fail weeks,

months or even years later. Special versions of software would contain viruses and time-delayed bugs that would make vital computers malfunction after a while. US intelligence also allowed the Soviets to steal faked secrets about stealth and space defence technologies. It didn't take long before the plan took effect.

The USSR had a new trans-Siberian oil pipeline under construction, and needed an automated system to properly manage it. They legitimately bought older models of computers on the open market and openly approached the US authorities for permission to buy the necessary software. The US refused, so the KGB stole it. However, the software they stole was a doctored version designed to become unstable. It would open valves unexpectedly and set pressures too high for the pipeline's welds.

After an initially successful deployment in which it functioned perfectly, the software malfunctioned on cue and the pipeline exploded. US infrared-detecting satellites put the resulting explosion at three kilotons; it appeared like a banned tactical warhead test or nuclear accident, but there was no evidence of a release of radioactivity.